

Reduced corticospinal inhibition following fatiguing exercise in professional cyclists

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INTRODUCTION

During fatiguing exercise in healthy humans, the central governor theory posits that the brain output slows before peripheral fatigue, leaving a central reserve. We proposed that highly trained athletes might have access to the central reserve through reduced corticospinal inhibition. The primary test to examine this was transcranial magnetic stimulation (TMS) with single pulse stimulation over the primary leg motor cortex during maximal quadriceps muscle activation in a fresh condition, and then immediately following exhaustive cycling exercise.

MATERIALS AND METHODS

In four professional cyclists (1 female, age 29-45), we tested the EMG silent period duration following the motor evoked potential (single-pulse TMS, Magpro MC-B70 coil) during five maximal voluntary isometric contractions (MVIC), in the fresh state and then repeated post exercise (4000m time trial, time range; 5min 10sec to 6min 5sec). Tests were conducted within a velodrome over two consecutive days, as part of a broader 5-day testing schedule involving both laboratory and velodrome testing. In addition, anodal transcranial direct current stimulation (2mA tDCS, anode Pz, cathode Fpz, pi electrodes; Starstim, Neurolelectrics) or sham was delivered prior to the pre-exercise baseline TMS, and was randomly ordered across subjects. Surface EMG (SX230, 20-1000Hz bandpass filter, Biometrics) was digitized at 2kHz and processed offline using Spike2 software (CED, UK), with manual cursoring of MEP amplitude and silent period duration. The study had Institutional Review Board approval from the Burke Rehabilitation Hospital.

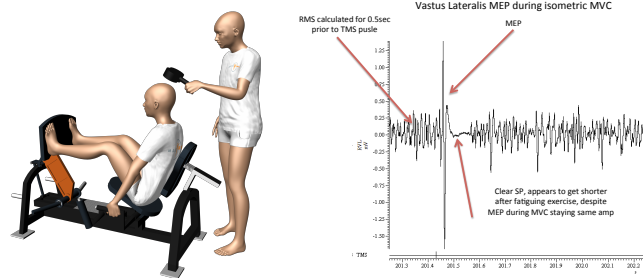


Figure 1. Approximation of athlete and scientist position for the maximal voluntary leg press and transcranial magnetic stimulation (TMS). Note, the leg press was single-leg, held for ~5 seconds, with TMS delivered when force output stabilized around maximum. Data represent the average of 5 contractions for the pre and post time-trial assessment.

Figure 2. Sample motor evoked potential from one subject during a maximal voluntary contraction. Following a single pulse of TMS. A biphasic motor evoked potential can be seen with greater amplitude than the ongoing EMG. This is followed by a period of EMG silence known as the silent period, where the duration provides a measure of cortical and spinal inhibitory network activity.

RESULTS

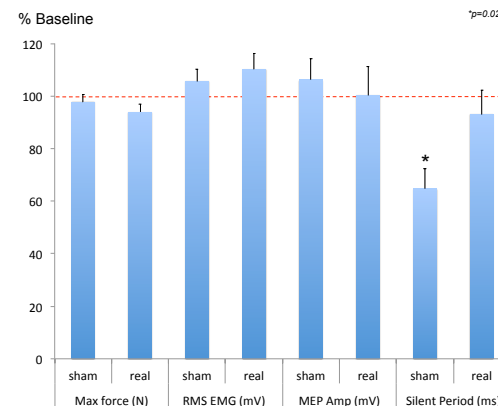


Figure 3. Group post time-trial data normalized to baseline. Force and EMG changes were negligible, subtle force decrement paralleled by subtle EMG increase. MEP amplitude also remained unchanged or marginally elevated. In contrast, silent period was substantially reduced. Results with prior real tDCS shows a similar pattern, however the silent period appears to be restored.

Prior sham tDCS									
	Max force (N)		RMS EMG (mV)		MEP Amp (mV)		Silent Period (ms)		
	Baseline	Fatigued	Baseline	Fatigued	Baseline	Fatigued	Baseline	Fatigued	
Subject 1	1019	924	0.33	0.34	4.03	4.17	92	41	
Subject 2	1614	1584	0.18	0.17	1.20	1.06	98	68	
Subject 3	761	794	0.09	0.11	0.42	0.53	83	66	
Subject 4	904	876	0.16	0.19	1.13	1.29	177	122	
average	1131	1101	0.20	0.21	1.88	1.92	91	59	
sterr	187	182	0.05	0.05	0.80	0.82	22	17	

Prior 2mA anodal tDCS									
	Max force (N)		RMS EMG (mV)		MEP Amp (mV)		Silent Period (ms)		
	Baseline	Fatigued	Baseline	Fatigued	Baseline	Fatigued	Baseline	Fatigued	
Subject 1	886	858	0.18	0.23	3.02	3.95	110	97	
Subject 2	2052	1782	0.27	0.28	1.51	1.25	69	66	
Subject 3	793	777	0.10	0.10	0.85	0.74	69	66	
Subject 4	1022	1034	0.19	0.22	1.08	1.02	100	56	
average	1243	1139	0.18	0.20	1.79	1.98	83	76	
sterr	292	230	0.03	0.04	0.49	0.75	11	9	

Table 1. Group raw data for sham and real tDCS testing days.

In the fatigued state, mean force production was $\leq 10\%$ decreased from baseline ($98 \pm 3\%$ baseline, sham tDCS condition; $94 \pm 3\%$ real tDCS), while RMS EMG was $\leq 10\%$ increased from baseline ($106 \pm 5\%$ baseline, sham tDCS condition; $110 \pm 6\%$ real tDCS; Fig 3). Similarly, MEP amplitude remained relatively unchanged or modestly increased ($106 \pm 8\%$ baseline, sham tDCS condition; $100 \pm 11\%$ real tDCS). EMG silent period however, showed a marked ($35 \pm 7\%$) reduction relative to baseline, that was less prominent in the tDCS condition ($7 \pm 9\%$ real).

Summary

- In this pilot study of four professional cyclists, during the post-exhaustive exercise recovery period, muscle force was surprisingly little affected (mild reduction only), and it was accompanied by a mild increase in sEMG and MEP amplitude. EMG silent period was shortened in every case, whether under the influence of tDCS or not.
- Using TMS, we did not find strong evidence of central reserve in a fresh or fatigued state. On the contrary, we found decreased corticospinal inhibition and associated with ability to maintain strong force output post-exercise. Decreased inhibition of brain output might be a contributing factor to the ability to sustain performance and overcome the central governor.
- Pre-exercise anodal tDCS appeared to normalize silent period toward baseline, but did not appear to substantially or consistently modify performance as measured by maximal force production or cycling performance time.